Advances in reticle cleaning

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Summary

We investigated the removal of carbon contamination on TaN structures on Si substrates with Shielded Microwave Induced Remote Plasma (SMIRP). For full reticle cleaning we investigated the cleaning homogeneity of our present plasma cleaning system and we believe that for this system we should be able to clean a full reticle within acceptable time and without too much over cleaning due to the inhomogeneity of the plasma source.

Introduction

Besides the requirement of defect free reticles for process development and High Volume Manufacturing, there is also a need to clean the reticles to enhance the reticle lifetime. A great effort has been put in developing cleaning processes for particles as well as molecular contamination. With the upcoming introduction of HVM EUV lithography the need for a working and integrated cleaning process is becoming extremely urgent. We are working on both problems, however this poster only shows our results on molecular cleaning

Cleaning homogeneity

Our plasma cleaning setup has a 26 cm microwave source, see figure 1 and we conducted research on the cleaning distribution below this source on a 30 x 30 cm square at a distance 16 cm below the source. The cleaning rate distribution is shown in figure 2. The cleaning rate was measured in a 10 min exposure with 500 W of average microwave power with a 50% duty cycle and hydrogen as feeding gas.

The cleaning rate experiments were performed with carbon coated 1" quartz optical flats and determined by measuring the transmission of the carbon before and after the experiment. For the full field a difference in cleaning rate of about a factor of two is observed between center and outer edge of the field. For the size of a reticle (6"x6") the difference is about 30% this should be sufficient for full reticle cleaning.

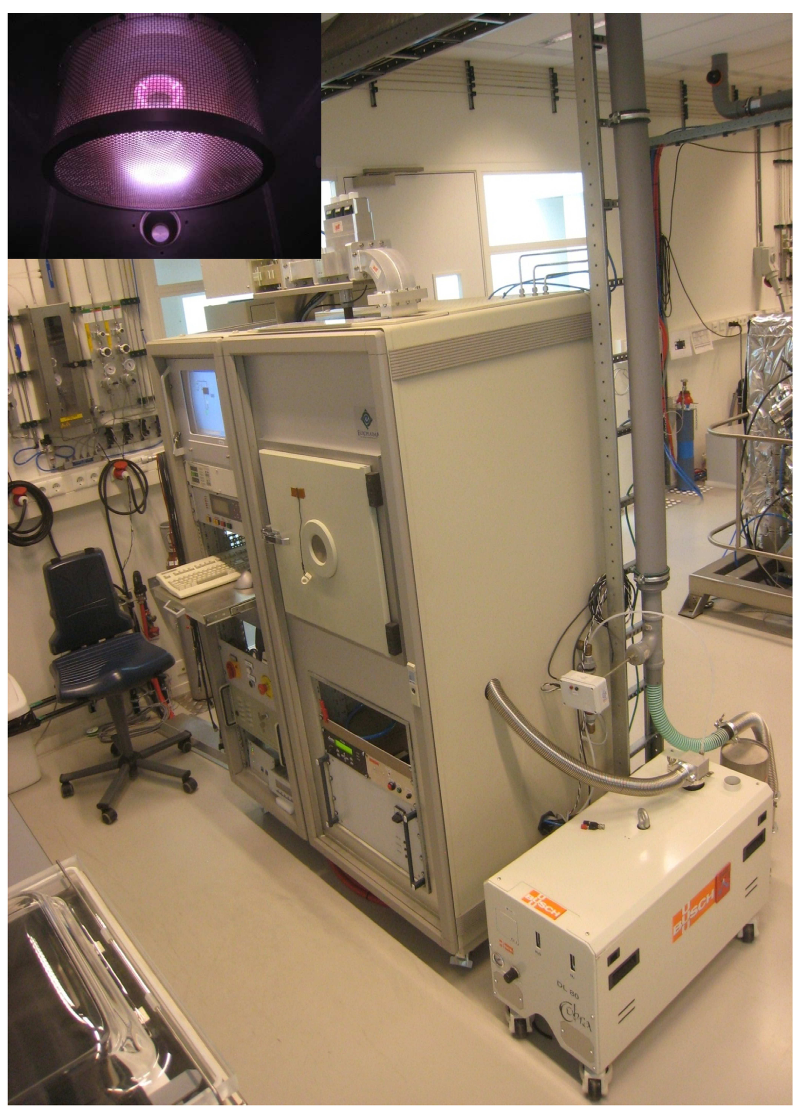

Figure 1: The plasma system at TNO

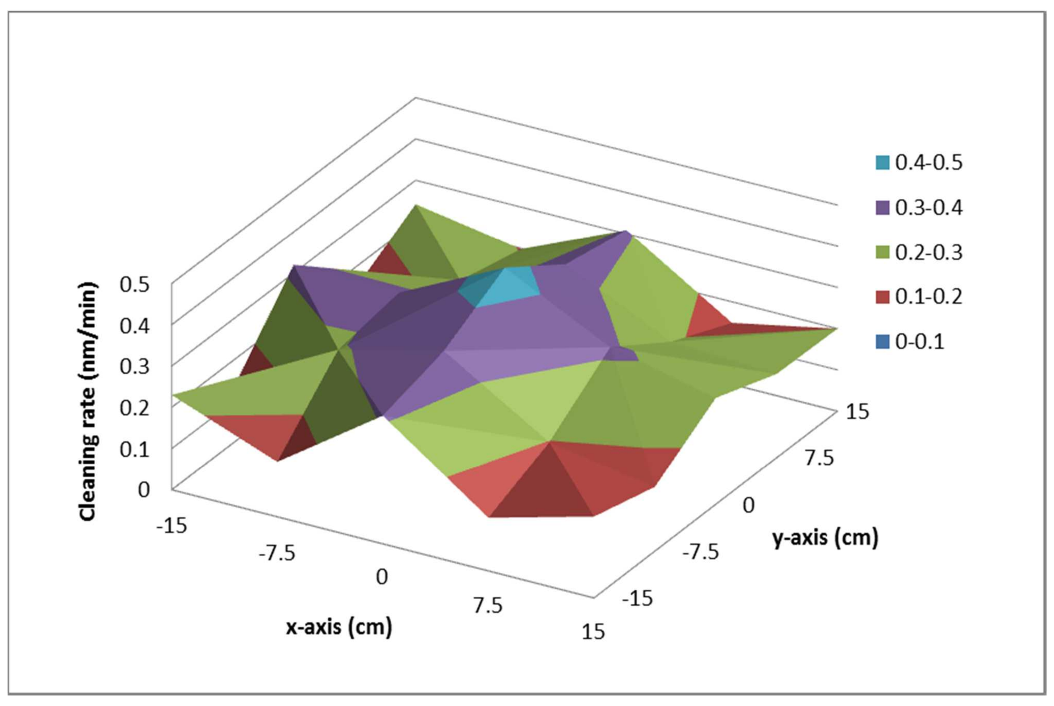

Figure 2 : Cleaning rate distribution at 16 cm from source

Carbon removal from structures

To study the efficiency of carbon removal on reticles we developed test structures in a TaN layer with different sizes and geometries, see figure 3. The TaN was deposited on Si wafers with an ALD process to ensure good homogeneity and high density. Besides structures we also made gratings with 500 nm trenches on a 1.8 µm spacing, in a 55 nm thick TaN layer. The carbon was grown in our e-gun set-up with dodecane as precursor gas, the estimated layer thickness was 10 nm and was verified by ellipsometry.

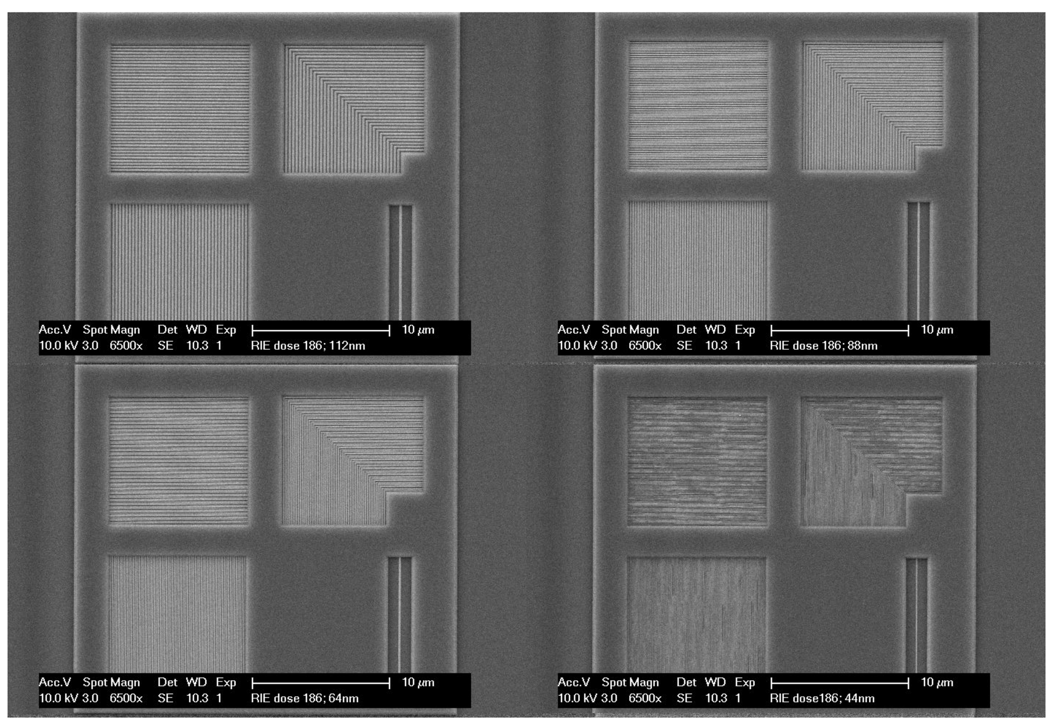

Figure 3: test structures with 112, 88, 64, 44 nm line width

On another grating with 800 nm lines and spaces we deposited 10 respectively 60 nm of carbon covering a complete field of the grating. From previous experiments we know that thick layers are harder to remove due to compacting of the layer. Cleaning rates as measured with the carbon coated quartz samples are therefore optimistic. The 10 nm sample was exposed for 26 hours to completely remove the deposit and imaged with SEM to see if there was remaining carbon in the trenches. As the SEM does not have enough contrast for carbon on TaN the results are inconclusive and the sample are now being investigated with micro analysis SIMS-SPM.

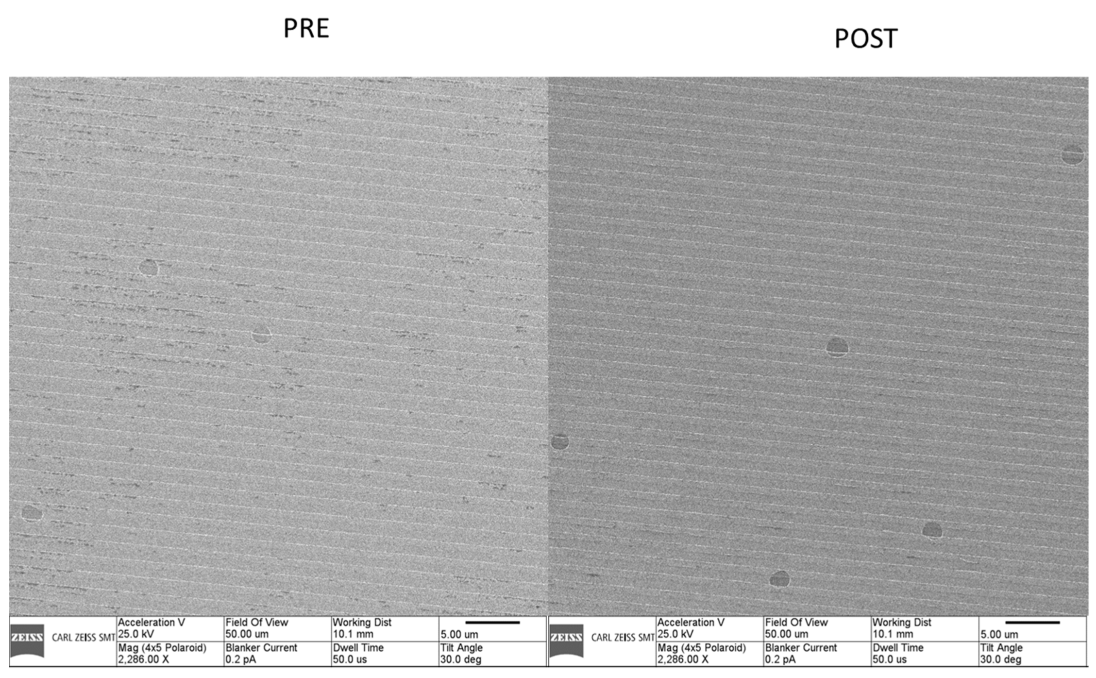

Figure 4: 1 hour plasma cleaning of 1,8 µm grating

The grating with 60 nm carbon was cleaned for a removal of 30 nm to study the possible difference in cleaning on top of the TaN absorber and inside the trenches. Results of the cleaning and pending for the micro SIMS-SPM analysis.

Outlook

Within the NanoNext program we intend to develop a cleaning method for both molecular as well as particle contamination. Especially the removal of particles and molecular contamination in the trenches is of particular importance for these methods to be successful. We will continue with test structures on 1"multilayers mirrors with home grown TaN absorber layers. Finally we will run full size reticles with patterns. In order to do this we are going to build new and modify existing equipment that is capable of holding and cleaning full size reticles.

Conclusion

We believe that this method shows good potential for solving the molecular contamination issues associated with HVM production. In combination with a particle removal method it seems feasible to develop a cleaning process for reticles which can be used in mask houses as well as in fabs.

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